Chapter 9
Maintenance Considerations

9-1. General

Vertical lift gates should be designed with consideration given to maintenance and inspection. Most gates, if properly designed, will be capable of performing for the service life of the structure. Access is a critical item when gates are inspected. These inspections provide a check of critical areas and identify when and what kind of maintenance is required. For new projects, the design of the gate should consider where and how access will be provided. For navigation lock gates, ladders on the downstream side of the gate are normally provided. This allows inspection of girders visible to the downstream side of the gate. To inspect or replace the end wheels, a watertight access cover in the guide slot should be provided. Outlet gates and spillway crest gates can be inspected as the gate is pulled from the gate slot.

9-2. Bulkheads

Bulkheads are placed upstream or downstream of vertical lift gates to serve as temporary damming structures while vertical lift gates are inspected or removed for service. This requires a bulkhead slot a short distance upstream (or on the pressure side) of vertical lift gates. Bulkheads are similar in construction to emergency gates except they do not have rollers or wheels since they are installed and removed under balanced head. A valve in the bulkhead or a valve and piping in the pier are required to provide equilizing head between the bulkhead and gate for bulkhead removal.

9-3. Lubrication

Wheel gates have either bronze sleeve or antifriction bearings. It is essential that provisions be made for lubrication of these bearings to seal them against entrance of water and silt. Lubrication should be performed on a regular basis and whenever the wheel gates are brought out of the water to ensure the bearings are continually filled with grease. Grease pipelines should be made to inaccessible and submerged grease fittings for lubrication when gates remain closed for long periods of time. Some gates use automatic lubrication systems where the gate experiences high usage in an environment that causes rapid deterioration of the bearings. Manual lubrication fittings would require excessive manual maintenance. For overhead vertical lift gates used in navigation locks, the bearing shoes are continuous along the length of the end post. These shoes have been lubricated to reduce friction for hoisting and to allow for expansion or contraction while under hydrostatic load. These generally employ automatic lubrication systems along the length of the shoes. Gates that use roller chains, as in tractor gates, are designed to operate without lubrication. Lubrication should be considered for dogging pivot points and push rod guides. Where they will be inaccessible, piping should be provided to allow lubrication at convenient locations.

9-4. Inspection

Engineering inspection requirements for gates are specified in ER 1110-2-8157. Gates that are otherwise inaccessible should be inspected whenever the gates are removed from the slots or while the water passage is out of service. During routine dam safety inspections, it may not be practical to inspect all gates for projects that have numerous spillway crest gates, outlet gates, or emergency intake gates (as in powerhouses). In those cases, checking one gate will give a good indication of the condition of the other gates. Where some gates have been rehabilitated more recently than others, one of the older gates and gates that are used more frequently should be checked. The downstream side of powerhouse emergency gates can also be inspected as part of the normal unit outage without being completely removed from the gate slot. The same can be accomplished with outlet gates. When the outlet tunnel is dewatered for inspection, a bulkhead should be placed to allow inspection of both sides of the outlet gate. Navigation lock gates should have a formal inspection during the dam safety inspections for the project. Periodic inspection reports should contain an inspection list of gates, dates, and condition of welds, coatings, fasteners, and wheels; and unusual conditions should be noted so that an overall condition history can be used to determine when scheduled maintenance should occur.

a. Structural inspection.

(1) End bearing. Since the main load transfer from the gate is through end bearing, that is the normal place for wear due to rotation from loading and unloading and expansion or contraction. Some vertical lift gates will transfer load through bearing shoes rather than rollers or wheels. The shoes may already be curved to handle end post rotation; however, excessive wear may cause portions of the end post or girders to bear directly on the guides. If this occurs, the guides will normally show excessive wear. Bolts or welds holding the bearing shoes in place should be inspected for damage or cracking. The only way to inspect this condition is to have the gate above the gate slot or recess.

(2) Structural and fracture critical members. Primary concern for structural members is their ability to safely carry the load throughout the life of the gate. Cracks developing on the tension side of flanges or plates are the primary cause of failure of members or gates. Prior to inspection of the gate, FCM's should be identified, with splices identified in the girder or skin plates. All splices should be carefully inspected for

cracks in welds, bolts, or rivets. Generally, fatigue will be the major contributor to cracking and failure of FCM's. Corrosion will also be a major contributor to a splice failure. If corrosion is occurring in welds or bolts, further investigation will be necessary to determine the extent of its effects and when repair should take place. Cracks in welds in FCM's shall be repaired in accordance with AWS D1.5 (AWS 1996a). Where a skin plate is on the downstream side of the gate, the skin plate becomes a tension member and the FCM. Splices in these skin plates become critical joints in highly stressed areas. These splices should be carefully examined for cracks. Often small cracks can be identified by rust forming along the hairline and are visible against a painted surface. Another major contributor to cracks forming on tension side flanges on navigation lock gates is where secondary bracing members have been welded to the flanges of horizontal members. Fatigue causes these cracks to propagate, some to complete failure of the member. During the inspection, the connection of secondary bracing to the flanges of the main horizontal girders should be carefully checked. Some gates have been designed with intermittent stitch welds for main horizontal girders to skin plates. Because they have not been seal welded, corrosion can occur between the flange and the skin plate. This condition should be noted.

(3) Joints. Critical joints for vertical lift gates occur in trussed or arched tension tied girders. Joints connecting the tension tie to the arch and truss members are subject to fatigue cracking. As with splices in FCM's, these joints should be carefully inspected for cracks forming along the weld or near the heat affected zone. These locations are usually identified as fracture critical and shall be repaired in accordance with AWS D1.5-96 (AWS 1996a).

(4) Welds and bolts. Older gates may have steel that contains material contents identified as ASTM A7. These steels have a higher carbon content than modern steels such as ASTM A36/A36M (ASTM 1996c). These gates were joined using rivets instead of welding. All bolts, rivets, cap screws, or other types of fasteners on the gate should be checked for tightness and corrosion. The presence of riveting is an indication that the older type of steel is present. Special attention should be given to corrosion, loose rivets, and the existence of small cracks beginning at rivet holes. This material can be joined by welding; however, the higher carbon content steel requires prequalifying welding procedures and a higher degree of inspection during the repair. Bolts require the same level inspection as rivets. Attention should be given to places where dissimilar materials are bolted or riveted together since galvanic corrosion occurs in these areas. All replacement bolts should be stainless steel and painted after installation. All repair of fracture critical welds shall follow welding procedures specified in AWS D1.5-96 (AWS 1996a). All other weld repairs should follow guidance specified in AWS D1.1-96 (AWS 1996b).

b. Other components.

(1) Coatings. Coatings commonly fail by pitting, blistering, flaking, peeling, and wear or abrasion. Discoloration of a coating is usually not serious, since the coating is still functional. EM 1110-2-3400 provides guidance for maintenance painting. The primary purposes for maintaining a good paint system for vertical lift gates are safety, extending the life of the gate, and protecting against unscheduled shutdowns. All visible areas of the gates including top, bottom, ends, skin plate, flange plates, and inside compartments should be checked. Often, the paint may not be peeled; however, significant rust and deterioration of steel may exist under the paint surface. The extent of the rust underneath will not be apparent unless the paint is peeled away to expose the damage. Further damage can be prevented if these areas are touched up, and not left for further deterioration.

(2) Anode condition. Anodes should be replaced when more than 50 percent is corroded. Anodes do not protect around corners. Thus, all anodes should be inspected and replaced if defective. Do not assume that adjacent anodes will perform the function of one that is inoperative. They will continue to function as long as magnesium is present and they are electrically connected to the gate by welding. All welds of anode core wire to the gate should be checked for soundness.

(3) Seal conditions. An inspection for leakage is one measure of the condition of seals. Seals are resistant to aging or weathering and usually suffer from abrasive wear or damage from misalignment when the gate is being raised or lowered. The inspection should include the face of the bulb that bears against the embedded seal plate to make sure that it has not been ground flat, and at the splice points to make sure they are still connected. Vulcanized factory splices rarely fail, but many gates have field splices made with a rubber cement, which do not develop the strength or durability of vulcanized splices. Many seals have a fluorocarbon strip vulcanized into the bearing face of the bulb to reduce sliding resistance. This should be checked to make sure it has not come loose. All steel supporting plates and bolts or flathead mounting screws should be inspected for tightness and soundness. Since bolts, cap screws, and nuts are stainless steel and the supporting plates are mild steel, inspect for corrosion caused by the dissimilar metals. Replace bolts with stainless steel type 304 (ASTM 1996d) and stainless steel nuts with NITRONIC 60 (ASTM 1996b). Paint all dissimilar metals with a submersible paint system after installation.

(4) Guide condition. Gate guides should be inspected during the same time the gate is being inspected. The most difficult inspection task is usually with pier guides in outlet type gates. They are submerged and require dewatering to inspect. Most guides are fabricated from stainless steel

exposed surfaces attached to embedded carbon steel bolts or framework. They are embedded in the concrete to tight tolerances and must transfer the gate load safely to the concrete structure. The seal plates must be straight and smooth so the rubber seals can provide a watertight fit when the gate is in place. The only part that is visible at most installations is stainless steel portions of the guides. Stainless steel should be passivated during fabrication prior to installation in the piers but may become active if the passive film is interrupted by conditions where oxygen is excluded. This occurs when the surface is contaminated with trash, silt, and mud, which causes corrosion due to adjacent active/passive areas. This differential aeration can be destructive to the 300 and 400 series stainless steels. The area where oxygen is excluded becomes the anode and the balance of the metal the cathode. Guides corrode at the highest rate at the bottom of the slot or at the splash zone when oxygen, velocity, and temperature combine under differential conditions. These areas should be closely examined during inspection. Some projects have high-pressure water jet systems for removing mud and silt from the bottom of the slot prior to each gate use. Systematic removal of floating debris will help prevent oxygen-starved areas at the water surface in the guide area at the splash zone. Embedded portions of the guides cause dissimilar metal contact, which can cause corrosion of the less noble metal. The exposed stainless steel is welded to embedded mild steel that contacts concrete reinforcing steel, which may come in contact with prestressed tendons, electrical conduits, fluid piping, and eventually the copper ground mat at the project. All are dissimilar metals in the presence of water since concrete is porous and saturated when submerged. This can cause corrosion under the exposed guide surface. Byproducts of steel corrosion occupy a volume many times the volume of the steel. An indication that the embedded portions are corroding would be spalling or swelling concrete around the guides and rust staining of the concrete. If swelling causes misalignment of the guides, the gate will not bear or seal properly, necessitating repair or replacement.

(5) Roller chain or wheel condition. Thorough inspection of roller chains and wheels is important since the ability of outlet or spillway gates to operate under full head is dependent on the proper functioning of the roller chain or wheels. Tractor type gates use a continuous roller chain on each side to transfer reaction forces to the embedded bearing plates. Many older gates use rollers that were built from type 410 stainless (ASTM 1996d), which is susceptible to cracking while in service. All gate roller chains should be checked for cracks and missing parts, such as retaining rings or keepers. The chain should have rollers that are free to turn on their shafts and side link bars that rotate freely where they join the roller shaft. The complete chain should have clearance between it and the bottom of the roller track so that it is free to move on the track. Fixed-wheel type gates use a series of fixed-position wheels on both sides of the gate to transfer reaction forces. These wheels are mounted on an eccentric pin so they can be adjusted to a proper position to bear equally on the embedded tracks. The wheels are made of cast steel and are mounted on bushings that fit on stainless steel pins. The wheels should be inspected for damage and cracks, making sure they can still turn freely. If wheels have grease fittings, check to see that they have been maintained.